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A study on the magnetic properties of Al-doped sulphur spinel

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$FeCr_{2-x}Al_xS_4$ ($0.1 \leq x \leq 0.5$) samples were prepared by solid state reaction method. The crystallographic structure and magnetic properties of the fabricated compounds were investigated by x-ray diffraction, superconducting quantum interference device (SQUID), and Mössbauer spectroscopy. The crystal structure is determined to be a cubic spinel with the space group of Fd-3m and the lattice constants a_0 = 9.998, 9.994, and 10.010 Å, respectively. The temperature dependence of magnetization, measured from 5 to 300 K, suggests that $FeCr_{2-x}Al_xS_4$ ($0.1 \leq x \leq 0.5$) samples show ferrimagnetic behaviour. The magnetization followed a Curie-weiss law with a positive Curie temperature θ_{cw} = 160 K, 141 K, and 129 K, respectively. $FeCr_2S_4$ spinel was known to exhibit ferromagnetism below T_N = 170 K [1]. The decrease of Néel temperature compared with $FeCr_2S_4$ could be interpreted by weakening of the exchange interaction by substitution of non magnetic Al ions. Mössbauer spectra of $FeCr_{2-x}Al_xS_4$ ($0.1 \leq x \leq 0.5$) were obtained at various temperatures ranging from 4.2 to 300 K. Magnetic hyperfine field and electric quadrupole interactions for x = 0.5 at 4.2 K have been fitted, yielding the following results: H_{hf} = 120 kOe, ΔE_Q = 2.27 mm/s, θ = 37.0°, φ = 10.0°, η = 1.0, and R = 2.8. The charge state of Fe ions for x=0.5 is ferrous (Fe^{2+}) as characterized by isomer shift δ = 0.72 mm/s at 4.2 K.

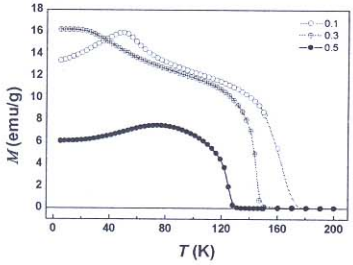

Figure 1: The temperature dependence of FC magnetization curves for the $FeCr_{2-x}Al_xS_4$ ($0.1 \leq x \leq 0.5$) with the external field of 100 Oe.

[1] S. Nakatsuji, H. Tonomura, K. Onuma, Y. Nambu, O. Sakai, Y. Maeno, R. T. Macaluso and J. Y. Chan, Phy. Rev. Lett. **99** (2007), 157203-1.

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